U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

6.1.1 ENGINEERED SAFETY FEATURES MATERIALS

REVIEW RESPONSIBILITIES

Primary - Materials Engineering Branch (MTEB)

Secondary - Chemical Engineering Branch (CMEB)

I. AREAS OF REVIEW

Engineered safety features (ESF) are provided in nuclear plants to mitigate the consequences of design basis or loss-of-coolant accidents, even though the occurrence of these accidents is very unlikely. The General Design Criteria (GDC) 1, 4, 14, 31, 35, 41 and Appendix B of 10 CFR Part 50, and 10 CFR Part 50, §50.55a require that certain systems be provided to serve as Engineered safety features (ESF). To meet GDC 14 the fluids used in ESF systems when interacting with the reactor coolant pressure boundary should have a low probability of causing abnormal leakage, rapidly propagating failure and of gross rupture. Containment systems, residual heat removal system, emergency core cooling systems, containment heat removal systems, containment atmosphere cleanup systems, and certain cooling water systems are typical of the systems that are required to be provided as ESF. The materials and fluids compatibility for these systems are reviewed in this Standard Review Plan (SRP) section. The General Design Criteria (GDC) establish functional requirements for specific systems. Specific acceptance criteria identified in subsection II of this SRP section establish the basis for acceptance of materials and fluids compatibility of the ESF systems.

The emergency core cooling system, the containment heat removal system, the containment cleanup systems and other ESF systems are described in Section 6 of the SAR and are reviewed in accordance with the SRP sections for the individual systems. The fluids compatibility and materials for these systems are reviewed in this SRP section.

The fluid and material compatibility for the auxiliary systems that directly support the ESF systems identified above, include systems such as the CCW, SW, ESF ventilation. These systems are reviewed in this SRP section upon request of the respective primary branch.

A. MTEB as primary reviewer uses the evaluations by CMEB to complete the overall review of ESF materials. MTEB review areas include the materials and fabrication procedures used in the design engineered safety features. The specific areas of review and review procedures are similar to those in SRP Section 5.2.3, "Reactor Coolant Pressure Boundary Materials," and to those in SRP Section 10.3.6, "Steam and Feedwater System Materials." The purpose of the review is to assure compatibility of the materials with the specific fluids to which the materials are subjected. The review is performed to assure compliance with the Commission regulations stated in the General Design Criteria and with the positions of applicable Regulatory Guides and Branch Technical Positions, and also with the ASME Boiler and Pressure Vessel Code (hereinafter "the Code"), Section II, parts A, B, and C, Section III, Division 1 and 2, and Section IX. Areas that are reviewed include: mechanical properties of materials (including fracture toughness), use of cold worked stainless steels, control of ferrite content in austenitic stainless steel welds, and control of ferritic steel welding.

B. CMEB reviews areas relating to ESF fluid chemistry, component and system cleaning, and thermal insulation used in the containment. The fluid chemistry, cleaning and insulation evaluations are furnished to MTEB for incorporation into the final SER. These are further described as follows:

1. <u>Composition and Compatibility of Engineered Safety Features Fluids</u>

The composition of the containment and core spray coolants must be controlled to ensure their compatibility with materials in the containment building, including the reactor vessel, reactor internals, piping, and structural and insulating materials. The methods and procedures to control the chemical composition of solutions recirculated within the containment after design basis accidents (DBA) must be selected (a) to maintain the integrity of the reactor coolant pressure boundary, by preventing stress corrosion cracking of safety-related components, (b) to insure that adequate solution mixing of ESF fluids will occur, and (c) to prevent evolution of excessive amounts of hydrogen within the containment in the unlikely event of a design basis accident.

The time history of the pH of the fluids, including the source and quantity of all soluble acids and bases in the containment after a design basis accident, is reviewed.

Containment and core spray solutions must be stable under long-term storage conditions and during prolonged operation of the sprays. Some of these solutions contain boron for reactivity control and other additives for reacting with gaseous fission products. Long-term storage of these solutions are reviewed under SRP Section 6.5.2 by CMEB as part of its secondary review responsibility.

In many instances the ESF coolant solutions are stored in more than one form (such as boric acid solution and a sodium hydroxide solution) and mixed only when the ESF are called upon to operate during an emergency. In some plants, the coolant is stored as a boric acid solution that is neutralized by (dry) sodium phosphates mounted in baskets inside the containment after the ESF sprays are activated.

The controls on contaminants, such as chlorides, lead, zinc, sulfur, or mercury, in the ESF fluids are reviewed. Nonmetallic thermal insulation, that will be exposed to ESF fluids in DBA environments is evaluated as a potential source of these contaminants.

CMEB reviews corrosion rates as related to hydrogen generation upon request of the Containment Systems Branch (CSB).

Compatibility of ESF fluids with organic materials (coatings) is reviewed by CMEB as part of its primary review responsibility for SRP Section 6.1.2.

2. Component and Systems Cleaning

CMEB reviews the requirements for the cleaning (shop and on-site) of materials and components, cleanliness control, and preoperational system cleaning and the procedures for lay-up of nuclear plant fluid systems. Requirements for the maintenance of system cleanliness of fluid systems and associated components during the operational phase of the nuclear power plant are also reviewed.

3. Thermal Insulation

CMEB reviews the composition of the non-metallic insulation and the control of leachable contaminants from the insulation. The branch also reviews the use of inhibitors to reduce the probability of stress corrosion cracking of automatic stainless steel components.

4. Coatings

CMEB reviews the use, and qualifications of the protective coatings used in containment as part of SRP Section 6.1.2. Peeling, flaking or delamination of coatings can result in clogging of ESF system strainers and spray nozzles and thereby stop or slow down the flow rates of the ESF fluids.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in subsection I of this SRP section are based on meeting the relevant requirements of General Design Criteria (GDC) 1, 4, 14, 31, 35, 41 and Appendix B, 10 CFR Part 50, and 10 CFR Part 50, §50.55a as described below:

General Design Criterion 1, and §50.55a, "Quality Standards and Records," and "Codes and Standards" - as they relate to quality standards being used for design, fabrication, erection and testing of ESF components and the identification of applicable codes and standards.

General Design Criterion 4, "Environmental and Missile Design Bases" - as it relates to compatibility of ESF components with environmental conditions associated with normal operation, maintenance, testing and postulated accidents, including loss-of-coolant accidents.

General Design Criterion 14, "Reactor Coolant Pressure Boundary - as it relates to design, fabrication, erection, and testing of the reactor coolant pressure boundary so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

General Design Criterion 31, "Fracture Prevention of Reactor Coolant Pressure Boundary" - as it relates to extremely low probability of rapidly propagating fracture and gross rupture of the reactor coolant pressure boundary.

General Design Criterion 35, "Emergency Core Cooling" - as it relates to assurance that the clad metal-water reaction is limited to negligible amounts.

General Design Criterion 41, "Containment Atmosphere Cleanup" - as it relates to control of the concentration of hydrogen in the containment atmosphere following postulated accidents to assure that containment integrity is maintained.

Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" - as it relates to the requirement that measures be established to control the cleaning of material and equipment in accordance with work and inspection instructions to prevent damage or deterioration.

Specific criteria necessary to meet the relevant requirements of GDC 1, 4, 14, 31, 35, 41, and Appendix B to 10 CFR Part 50 and 10 CFR Part 50, §50.55a for the review areas identified in subsection I of this SRP section are as follows.

A. Criteria for Primary Review Areas

1. Materials and Fabrication

To meet the requirements of General Design Criterion 1 and §50.55a to assure that structures, systems and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed, Codes and standards should be identified and records maintained. The materials specified for use in these systems must be as given in Appendix 1 to Section III of the Code, and parts A, B and C of Section II of the Code.

Regulatory Guide 1.85, "Code Case Acceptability ASME Section III Materials," describes acceptable Code cases that may be used in conjunction with the above specifications. Fracture toughness of the materials shall be as stated in SRP Section 10.3.6, subsection II.1.

a. Austenitic Stainless Steels

To meet the requirements of GDC 4 relative to compatibility of components with environmental conditions; GDC 14 with respect to fabrication and testing of the reactor coolant pressure boundary so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture; and the quality assurance requirements of Appendix B of 10 CFR Part 50 the following guidelines should be used:

1. Cold worked austenitic stainless steels must have a maximum 0.2% offset yield strength of 90,000 psi to reduce the probability of stress corrosion cracking in ESF systems.

Laboratory stress corrosion test and service experience provide the basis for this criteria.

2. Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel," describes acceptable criteria for preventing intergranular corrosion of stainless steel components of the ESF. Furnace-sensitized material should not be allowed in the ESF, and methods described in this guide should be followed for testing the materials prior to fabrication, and for ensuring that no deleterious sensitization occurs during welding.

3. Branch Technical Position MTEB 5-7, "Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," describes acceptable criteria for the use of austenitic stainless steel piping in boiling water reactors. (See SRP Section 5.2.3.)

4. Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal," describes acceptable criteria for assuring the integrity of welds in austenitic stainless steel ESF components. The control of delta ferrite content of weld filler metal is specified in this guide, which sets forth an acceptable basis for delta ferrite content of weld filler metal.

b. Ferritic Steel Welding

To meet the requirements of General Design Criterion 1 related to general quality assurance and Codes and Standards, Appendix B to 10 CFR Part 50, related to control of special processes; and 10 CFR Part 50, §50.55a, "Codes and Standards," the following acceptance criteria for ferritic steel welding should be used:

1. The amount of minimum specified preheat must be in accordance with the recommendations of the Code, Section III, Appendix D, Article D-1000, and Regulatory Guide 1.50, "Control of Preheat Temperature for Welding Low-Alloy Steel," unless an alternate procedure is justified.

2. Moisture control on low hydrogen welding materials shall conform to the requirements of the Code, Section III, Articles NB, NC, ND-2000 and 4000, and AWS D1.1, "Structural Welding Code," unless alternate procedures are justified.

3. For areas of limited accessibility, the criteria of SRP Section 10.3.6, subsection II.2.c shall apply.

B. Criteria for Secondary Review Areas

1. Composition and Compatibility of Engineered Safety Feature Fluids

In meeting the requirements of General Design Criteria 4 and 41, that structures, systems, and components important to safety are designed to accommodate the effects of and to be compatible with environmental conditions associated with normal operation, maintenance, testing and postulated accident conditions, including loss-of-coolant accidents and to assure that the concentration of hydrogen in the containment atmosphere following postulated accidents is controlled to maintain containment integrity, the hydrogen generation resulting from the corrosion of metals by the containment sprays during design basis accident should be controlled as described in Regulatory Guide 1.7; "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident."

a. <u>Pressurized Water Reactors (PWRs)</u>

To meet the requirement of GDC 4, 14, and 41, the composition of containment spray and core cooling water should be controlled to ensure a minimum pH of 7.0 as given in Branch Technical Position MTEB 6-1 which is appended to this SRP section. Experience has shown that maintaining the pH of borated solutions at this level will help to inhibit initiation of stress corrosion cracking of austenitic stainless steel components.

The hydrogen generation from the corrosion of materials within containment, such as aluminum and zinc, depends upon the corrosion rate which in turn depends upon such factors as the coolant chemistry, the coolant pH, the metal and coolant temperature, and the surface area exposed to attack by the coolant.

The reviewer compares the assumed corrosion rates of materials in containment with standard corrosion rate data.

b. <u>Boiling Water Reactors (BWRs)</u>

To meet the requirements of GDC 4, 14, and 41, the water used in the engineered safety feature systems should be controlled to provide assurance against stress corrosion cracking of unstabilized austenitic stainless steel components. Water used for emergency core cooling systems and spray systems should be controlled to ensure the following limits:

Conductivity = 3 to 10 μhos/cm @ 25°C

Chloride (Cl^-) < 0.50 ppm

pH = 5.3 to 8.6 @ 25°C

Hydrogen generation in BWR containments is assumed to follow the same characteristics as in PWRs in that the rates of hydrogen generation will rise with increasing zinc corrosion as the temperature rises, and will change with any change in pH.

2. <u>Component and Systems Cleaning</u>

To meet the requirements of Appendix B to 10 CFR Part 50, measures should be established to control the cleaning of material and equipment in accordance with work and inspection instructions to prevent damage or deterioration.

Components and systems are to be cleaned in conformance with the positions of Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning Fluid Systems and Associated Components of Water Cooled Nuclear Power Plants."

3. Thermal Insulation

To meet the requirements of General Design Criteria 1, 14, and 31 so that the reactor coolant pressure boundary is designed, fabricated, erected, and tested so as to have extremely low probability of abnormal leakage, of rapidly propagating failure, and gross rupture, the following guidelines should be used:

a. The composition of nonmetallic thermal insulation for components of ESF should be controlled as described in Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel."

b. The use of nonmetallic insulation on nonaustenitic stainless steel components should be controlled as above. The moisture dripping from wet insulation on any component can affect austenitic stainless steel that is at a physically lower elevation.

c. Concentrations of leachable contaminants and added inhibitors should be controlled as specified in position C.2.b and Figure 1 of Regulatory Guide 1.36 to reduce the probability of stress corrosion cracking of austenitic stainless steel components.

4. Coatings

Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Processing Plants," establishes overall quality assurance program requirements for the design, fabrication, construction, and testing of safety-related nuclear power plant structures, systems, and components.

Section IX of Appendix B relates to the control of special processes. Coating systems are deemed to fall in this category.

The qualification program for coating systems should confirm that the systems used on ESF will not possibly stop or slow down the flow rates of the ESF fluids during a design basis accident.

Identified quantities of soluble acids and bases within the containment must not be great enough to cause excessive hydrogen generation or deleterious corrosion.

The criteria for coatings to be used in containments are described in Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants."

This guide describes an acceptable means for meeting the requirements of Appendix B to 10 CFR Part 50 stated above, with regard to protective coatings applied to ferritic steels, aluminum, stainless steel, zinc-coated (galvanized steel) concrete or masonry surfaces of water cooled nuclear power plants.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from the procedures described below, as may be appropriate for a particular case.

To ascertain that the acceptance criteria given in subsection II of this SRP section are met, the reviewer examines each of the review areas given in subsection I of this SRP section for the required information, using the following procedure:

A. Primary Review Area

The MTEB reviewer verifies that the materials proposed for the ESF are in conformance with Appendix I of Section III of the Code, and with parts A, B, and C of Section II of the Code. He verifies that cold-worked austenitic stainless steels used in fabrication of the ESF are in conformance with subsection II.A.1.a of this SRP section.

The methods of controlling sensitized stainless steel in the ESF systems are examined by the reviewer who verifies that the methods are in conformance with Regulatory Guide 1.44. This applies especially to the verification of nonsensitization of the materials, and to the qualification of welding procedures using ASTM A262. If alternative methods of testing the qualification welds for degree of sensitization are proposed by the applicant, the reviewer determines if these are satisfactory, based on the degree to which the alternate methods provide the needed results.

The methods for controlling the amount of delta ferrite in stainless steel weld deposits are examined by the MTEB reviewer in accordance with Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal."

The reviewer verifies that the controls of ferritic steel welding are in conformance with subsection II.A 1.b of this SRP section. The reviewer verifies that the fracture toughness of the materials is in accordance with the requirements of the Code.

B. Secondary Review Area

1. Composition and Compatibility of Engineered Safety Features Fluids

The reviewer (CMEB) considers the composition of the spray solutions and any mixing processes that might occur during operation of the sprays.

The reviewer (CMEB) examines the information on the compatibility of the ESF materials of construction with the ESF fluids to verify that all materials used are compatible.

The reviewer (CMEB) verifies that components and systems are cleaned in accordance with Regulatory Guide 1.37.

The reviewer (CMEB) determines whether non-metallic thermal insulation will be used on components of the ESF, and if it is, the reviewer verifies that the amount of leachable impurities in the specified insulation will be within the "acceptable analysis area" of Figure 1 of Regulatory Guide 1.36, as discussed in subsection II.B.3 of this SRP section.

The reviewer (CMEB) verifies that the coatings used in the containment conform with Regulatory Guide 1.54.

a. Pressurized Water Reactors (PWRs)

The reviewer determines that the coolant spray will have a minimum pH of 7.0 and reviews the methods of ascertaining that the pH will remain above this minimum during the operation of the sprays. The reviewer examines the control of pH of such coolants to evaluate the short-term (during the mixing process) compatibility and long-term compatibility of these sprays with all safety-related components within the containment.

The reviewer examines the methods of storing the ESF fluids to determine whether deterioration will occur either by chemical instability or by corrosive attack on the storage vessel. The reviewer determines what effects such deterioration could have on the compatibility of these ESF coolants with both the ESF materials of construction and the other materials within the containment.

CMEB further verifies that hydrogen release is controlled in accordance with Regulatory Guide 1.7.

The reviewer also compares the assigned corrosion rates of materials in containment, as stated in the SAR, with standard corrosion rate data. In accordance with the procedures in SRP Section 6.5.8 the reviewer examines the paths that the solutions would follow in the containment from sprays and emergency core cooling systems to the sump, for both injection and recirculation phases to verify that no areas accumulate very high or low pH solutions and that any assumptions regarding pH in the modeling of containment spray fission product removal are valid.

b. Boiling Water Reactors (BWRs)

The reviewer verifies that the chemistry of the water used for the emergency core cooling systems and the containment spray systems is controlled to the limits given in subsection II.B.1.b. The reviewer further verifies that hydrogen release is controlled in accordance with Regulatory Guide 1.7. The reviewer also compares the assumed corrosion rates of materials in containment with standard corrosion rate data.

IV. EVALUATION FINDINGS

The staff concludes that the engineered safety features materials specified are acceptable and meet the requirements of GDC 1, 4, 14, 31, 35, and 41 of Appendix A of 10 CFR Part 50; Appendix B of 10 CFR Part 50, and 10 CFR Part 50, §50.55a. This conclusion is based on the following:

1. General Design Criteria 1, 14, and 31, and 10 CFR Part 50, §50.55a have been met with respect to assuring an extremely low probability of leakage, of rapidly propagating failure and of gross rupture. This is shown since the materials selected for the engineered safety features satisfy Appendix I of Section III of the ASME Code, and Parts A, B, and C of Section II of the Code, and the staff position that the yield strength of cold-worked stainless steels shall be less than 90,000 psi. Fracture toughness of the ferritic materials meets the requirements of the Code.

   The controls on the use and fabrication of the austenitic stainless steel of the systems satisfy the requirements of Regulatory Guide 1.31, "Control of Ferrite Content of Stainless Steel Weld Metal," and Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel." Fabrication and heat treatment practices performed in accordance with these requirements provide added assurance that the probability of stress corrosion cracking will be reduced during the postulated accident time interval.

   Conformance with the Codes and Regulatory Guides and with the staff positions mentioned above, constitute an acceptable basis for meeting the requirements of General Design Criteria 1, 4, 14, 35, and 41; Appendix B to 10 CFR Part 50, and 10 CFR Part 50, §50.55a, in which the systems are to be designed, fabricated, and erected so that the systems can perform their function as required.

2. General Design Criteria 1, 14, and 31 and Appendix B to 10 CFR Part 50 have been met with respect to assuring that the reactor coolant boundary and associated auxiliary systems have an extremely low probability of leakage, of rapidly propagating failures and of gross rupture. The controls placed on concentrations of leachable impurities in non-metallic thermal insulation used on components of the Engineered Safety Features are in accordance with the requirements of Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steels." Compliance with the requirements of Regulatory Guide 1.36 form a basis for meeting the requirements of GDC 1, 14 and 31.

   The protective coating systems have been qualified by tests acceptable to the staff. This qualification provides reasonable assurance that the coating systems will not degrade the operation of the ESF by delaminating, flaking or peeling.

   The coatings applied are in accordance with Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants."

   Conformance with this Regulatory Guide provides a basis for meeting the requirements of Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."

3. The requirements of GDC 4, 35, and 41 and Appendix B, 10 CFR Part 50 have been met with respect to compatibility of ESF components with environmental conditions associated with normal operation, maintenance, testing and postulated accidents, including loss-of-coolant accidents since the controls on the pH and chemistry of the reactor containment sprays and the emergency core cooling water following a loss-of-coolant or design basis accident, are adequate to reduce the probability of stress corrosion cracking of the austenitic stainless steel components and welds of the engineered safety

features systems in containment throughout the duration of the postulated accident to completion of cleanup.

Also, the control of the pH of the sprays and cooling water, in conjunction with controls on selection of containment materials, is in accordance with Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident," and provides assurance that the sprays and cooling water will not give rise to excessive hydrogen gas evolution resulting from corrosion of containment metal or cause serious deterioration of the materials in containment.

The controls placed upon component and system cleaning are in accordance with Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants," and provide a basis for the finding that the components and systems have been protected against damage or deterioration by contaminants as stated in the cleaning requirements of Appendix B, 10 CFR Part 50.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternate method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of Commission regulations.

Implementation schedules for conformance to parts of the methods discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, "General Design Criteria," and Appendix B, "Quality Assurance Requirements for Nuclear Power Plants and Fuel Reprocessing Plants."

2. ASME Boiler and Pressure Vessel Code, Section II, Parts A, B, and C, Section III, Division 1, including Appendix I, Section III, Division 2, and Section IX, American Society of Mechanical Engineers.

3. ASTM A-262, "Detecting Susceptibility to Intergranular Attack in Stainless Steel," Annual Book of ASTM Standards, Part 3, American Society for Testing and Materials.

4. AWS D1.1, "Structural Welding Code," American Welding Society.

5. Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident."

6. Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal."

7. Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel."

8. Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants."

9. Regulatory Guide 1.44, "Control of the Use of Sensitized Steel."

10. Regulatory Guide 1.50, "Control of Preheat Temperature for Welding Low-Alloy Steel."

11. Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants."

12. Standard Review Plan Section 3.11, Appendix, "Chemical and Radiological Environment in Containment During Postulated Accidents."

13. Standard Review Plan Section 5.2.3, "Reactor Coolant Pressure Boundary Materials."

14. Standard Review Plan Section 6.2.5, "Combustible Gas Control in Containment."

15. Standard Review Plan Section 6.5.2, "Containment Spray as a Fission Product Cleanup System."

16. Standard Review Plan Section 10.3.6, "Steam and Feedwater Systems Materials."

17. Branch Technical Position MTEB 5-7, "Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping" (attached to SRP Section 5.2.3).

18. Branch Technical Position MTEB 6-1, "pH for Emergency Coolant Water For PWRs," attached to this SRP section.

BRANCH TECHNICAL POSITION MTEB 6-1

pH FOR EMERGENCY COOLANT WATER FOR PWRs

A. Background

To establish the minimum value of pH in post-accident containment sprays in pressurized water reactors, the Chemical Engineering Branch has reviewed the available information and recommended the criteria listed in the Branch Technical Position below.

The minimum pH value of 7.0 follows from the Westinghouse report (Ref. 1) conclusion that, in ECCS solutions adjusted with NaOH to pH 7.0* or greater, no cracking should be observed at chloride concentrations up to 1000 ppm during the time of interest. Figure 7 of the Westinghouse report shows that the time for initiation of cracking of sensitized and nonsensitized U-bend specimens of Type 304 austenitic stainless steel in solutions of 7.0 pH having 100 ppm chloride was 7-1/2 months and 10 months, respectively.

The great majority of tests reported in the Oak Ridge report, Reference 2, were performed with pH of 4.5, and only two tests were conducted with pH values other than 4.5. Some cracking was observed at pH 7.5 in the sensitized 304 stainless steel U-bend specimens after 2 months exposure to pH 7.5 and chloride concentration of 200 ppm. All of the 316 stainless steel specimens showed no evidence of cracking. Considering the fact that in U-bend specimens the material was sensitized, stressed beyond yield, and plastically deformed, we conclude that the reported test conditions were much more severe than the stress conditions likely to exist in the postaccident emergency coolant systems.

We agree with the Oak Ridge conclusion that absolute freedom from failure of any complex system such as a spray system can never be guaranteed, but, by proper design, fabrication, and control of the corrosive environment, the probability of failure can be significantly reduced. Our recommended minimum pH is somewhat higher than the Oak Ridge recommendation of a minimum of 6.5.

B. Branch Technical Position

CMEB criteria for pH level of postaccident emergency coolant water to reduce the probability of stress-corrosion cracking of austenitic stainless steel components, nonsensitized or sensitized, nonstressed or stressed, are as follows:

1. Minimum pH should be 7.0.

2. For the spray water recirculated from the containment sump, the higher the pH in the 7.0 to 9.5 range, the greater the assurance that no stress corrosion cracking will occur. See SRP Section 6.5.2 for additional water chemistry requirements related to fission product removal.

3. If a pH greater than 7.5 is used, consideration should be given to the hydrogen generation problem from corrosion of aluminum in the containment.

*All pH values are at 25°C.

C. Evaluation Findings

The controls on the pH and chemistry of the reactor containment sprays and ECCS solutions meet the staff positions on postaccident chemistry requirements for PWR emergency coolant water. It also meets the requirements of GDC 14 for assuring the low probability of abnormal leakage or failure of the reactor coolant pressure boundary and safety-related structures. We conclude that the proposed pH for emergency coolant water is acceptable.

D. References

1. D. D. Whyte and L. F. Picone, "Behavior of Austenitic Stainless Steel in Post Hypothetical Loss of Coolant Environment," WCAP-7798-L, Westinghouse Nuclear Energy Systems, November 1971 (NES Proprietary Class 2).

2. J. C. Griess and E. E. Creek, "Design Considerations of Reactor Containment Spray Systems - Part X, The Stress Corrosion Cracking of Types 304 and 316 Stainless Steel in Boric Acid Solutions," ORNL-TM-2412, Part X, Oak Ridge National Laboratory, May 1971.